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SCIENCE-TEACHING IN THE SCHOOLS.¹

BY WM. NORTH RICE.

THE word "schools" is here used in distinction from the higher institutions—colleges, universities and technological institutes. It will be convenient for us further to distinguish the "high schools" from the lower schools. As here used, the phrase "high school" designates a school whose pupils range from thirteen or fourteen to seventeen or eighteen years of age, and which professes to prepare students for the colleges and scientific schools.

In considering what should be the course of study in the schools, it is necessary to recognize the distinction in scope and spirit between general and special education. By general education is meant such education as is intended to prepare a person for the duties of manhood or womanhood, irrespective of any particular trade, profession, or station in life. By special education is meant such education as is intended to prepare a person for some particular trade, profession, or station in life. The courses of study in the schools must be, in this sense, general. We are not to try in the schools to make biologists, geologists, nor chemists. We are not to make physicians, nor engineers, nor lawyers, nor clergymen. Very few of the children in the schools will enter any of these professions; and, of that few, still fewer are aware of their destiny. But all the children in our schools have the expectation of growing up to manhood or womanhood. They will take their places in the

¹ Address at the meeting of the American Society of Naturalists, in New Haven, Conn., December, 1887, by William North Rice.

ranks of those who earn an honorable livelihood by honest labor, or among those whom vice or improvidence renders a burden to society. Those of one sex, by the possession of the right of suffrage, and those of both sexes, by their share in that informal and unregulated vote which we call public opinion, will in their degree shape the institutions of the land. Most of them will marry, and, by the direct effect of heredity, and by manifold influences of conscious and unconscious education, will mould the character of future generations. All of them must make individually the momentous pilgrimage through this mortal life to the solemn mysteries beyond. The arrangements of the schools must be adapted to the common needs of humanity, not to the peculiar tastes and conditions of individuals. There must be one course for the children of the rich and the poor, the learned and the ignorant. Such an average course will not be the best for every child, but it will be the best practicable for the great body of children. To employ private tutors, and adapt the educational course to the supposed tastes or needs of each individual child, is impossible for the poor, and generally undesirable for the rich. The advantage to the child from being in a class of reasonable size, feeling the stimulus of intellectual competition, and learning the truly democratic lesson that only personal merit can win, is worth (except in case of children of feeble health or very peculiar constitution) far more than any advantage which can come from the adaptation of the work of a private tutor to the child's idiosyncracies. In regard to the necessity of a uniform course of study, the high schools form a partial exception. In the high schools it becomes practically necessary to provide two courses of study—one for those who are preparing for the classical courses in the colleges, the other for those who are preparing for the scientific courses in the colleges and technological schools, or whose schooling is to be finished with the high school. To a limited extent, also, elective studies may be introduced into the high school course.

In the past, two theories have been maintained in regard to the proper aim and spirit of a general educational course. The disciplinary theory is that the object of general education is to train the mental faculties, it being assumed that a vigorous and well-disciplined mind is the best preparation for all work that may be

required of a man. The practical theory is that the object of education is to furnish the necessary information for the guidance of one's conduct in all probable circumstances. Of late it has been recognized that these views are not mutually exclusive, and that a true theory of education must combine the two. The shield is both gold and silver. A right education must be both disciplinary and practical.

But this harmonizing of the once hostile theories has not been effected without important modifications of each. On the one hand, the advocates of the disciplinary theory have come to recognize the truth that mental discipline can be obtained not merely from the study of some two or three subjects, but from the study of almost any subject. It is coming to be admitted that, from the disciplinary standpoint, the important question is not what we study, but how we study. The very same mental faculties may be disciplined, and disciplined in ways remarkably similar, in dealing with the most widely different subjects. The reasoning by which the comparative philologist traces the evolution of languages is strikingly analogous to that by which the comparative anatomist traces the evolution of organic structures. On the other hand, the advocates of the practical theory have been compelled to a broader and higher view of utility than the merely bread-and-butter view. The individual man is at once body and soul; and he comes into relations with the material universe, with his fellow-men, and with that unseen Power wherein nature and man alike live and move and have their being. Whatever may be known or believed with reasonable probability in regard to the human body, and in regard to the laws of that material universe with which it is related,—in regard to the human mind, whether as self-revealed in consciousness, or as indirectly manifested in literature and history—in regard to the Creator, whether made known by the facts of nature, or by a historic revelation—all this aggregate of varied knowledge and belief is in the highest and best sense practical, for it all tends to guide the conduct of life.

The claim of any particular branch of study to a more or less prominent position in the curriculum of the schools must accordingly be tried by a twofold criterion—its power to afford an effective mental discipline, and the practical utility of the information which it conveys.

It would be obviously a waste of time to discuss the practical utility of the sciences of nature. In this age of steam and electricity—this age of aniline dyes and anæsthetics and antiseptics—this age when science is multiplying comforts and conveniences and amenities, stamping out zymotic diseases, and largely increasing the duration of the life which it beatifies and ennobles—no one is so stupid as to deny the utility of scientific knowledge.

A few words may with propriety be said in regard to the disciplinary value of the study of the natural sciences, for in some minds still lingers the superstition that no studies are disciplinary except languages and mathematics.

The natural sciences are unique in their power of training the perceptive faculties. When these sciences are rightly taught, the student is brought face to face with natural phenomenon, which he is required to observe and describe. The perceptive faculties are not, indeed, the highest of human faculties, but they are by no means to be despised. A student who has learned to observe and describe correctly so simple a matter as the form of a leaf, has gained a power which will be of lifelong value, whatever may be his sphere of professional employment. If the student is required to write descriptions of observed phenomena, there may be gained incidentally a discipline in perspicuity and precision of expression, which will be of no trifling value.

The natural history sciences afford an unrivaled training to the powers of comparison and classification. Sometimes, indeed, these sciences have been called distinctively the classificatory sciences. They have been (at least since the publication of Darwin's epoch-making work) vastly more than mere classifications. They are truly dynamical sciences, revealing the processes whereby organic nature has attained its present state. But they are nevertheless in a very important sense classificatory sciences. In no other class of subjects has classification been so minutely elaborated. No student can learn to marshal the array of species into genera, families, orders, classes, and sub-kingdoms, as men are marshaled in the companies, regiments, brigades, and divisions of a well-disciplined army, without acquiring a more systematic habit of thought on any subject which may engage his attention. But the elaborateness of natural history classification is not the only feature of value in this

connection. The student is continually taught to distinguish not only degrees but kinds of resemblance and difference,—to distinguish those features of structure which are adaptive and superficial from those which are typical and fundamental,—to distinguish analogies from homologies. No one can learn to recognize the mammalian character of a whale under the disguise of its fish-like form, or to recognize the crustacean character of a barnacle under the disguise of its oyster-like shell, without becoming in general a sounder thinker.

The sciences of nature afford a valuable discipline to the reasoning faculties. Educators have always endeavored to afford a two-fold training in reasoning—a passive discipline, by requiring the student to familiarize himself with examples of reasoning recorded in the works of great thinkers; and an active discipline, by submitting to the student problems for solution, which, if not new to the human intellect in general, are at least new to the intellect of the particular student. The study of mathematics has always, and deservedly, been highly esteemed for the facilities which it offers for both these kinds of training. But the sciences of nature also have their splendid examples of reasoning. An intelligent study of Darwin's "*Origin of Species*" is perhaps not inferior as a logical praxis to the study of elementary geometry. Indeed, in one respect the former is superior, for the reasoning of natural sciences is more nearly akin than that of mathematics to the reasoning of practical life. And the sciences of nature have their problems in which the reasoning faculties of the student may find an active discipline. Every laboratory experiment should be an exercise in reasoning as well as in observation. A logical interpretation should be required as much as an accurate description of the phenomena. Moreover, the continual inculcation of the doctrine which is the very keynote of science—the doctrine that there is no such thing as chance—that all events are linked together in chains of cause and effect—is itself an education in philosophical thinking and in rational acting.

Not to be ignored is the influence of the natural sciences on the esthetic nature. There are indeed some scientific men—animated cases of dissecting tools and locomotive microscopes—who can contemplate nature without admiring her. But, for most of those

whose attention is attracted to nature, her aspect is multiform, and her speech many-tongued. And the devotee of nature's truth is ever delighted with the rich stores of nature's beauty. It is no mere accident that the same generations of mankind that have developed the sciences of nature have developed two new arts—landscape-painting, and the poetry of nature. There is inspiration for the imagination, as well as satisfaction for the understanding, in the contemplation of that far-reaching reign of law which is at once the fundamental postulate and the crowning induction of science. The old myth of the music of the spheres is only a parable of the all-pervading harmony of natural law.

Nor is the study of science without its wholesome influence upon the moral nature. Science is indeed no patent panacea for human depravity; but no one can become imbued in any measure with the spirit of science—the spirit of unselfish, courageous, reverent truth-seeking—without some degree of moral uplifting. I believe that a comparative study of biography will show that flagrant immorality has been exceedingly rare among scientific men—much rarer than among men of equal intellectual eminence devoted to literature, art, or almost any other pursuit. Literature and art may express and incite the basest passions. Science—truth—is never impure.

The claim of natural science to a prominent position in the educational course is now pretty fairly conceded in the higher institutions of learning. The most conservative of the colleges are making liberal provision of instructors and of material facilities for the teaching of the sciences, and the student is required or allowed to devote a large share of his time to this class of studies, while numerous scientific schools are open for those students who wish to devote a still larger share of their time to scientific study. The case, however, is very different in the lower schools. Somewhat of science is usually taught in the high schools, though not, as a rule, to those who are preparing for college. But in the lower schools there is usually little or no teaching of science. The result is that those whose educational course ends before they reach the high school (the great majority of the population) receive no instruction in science whatever, and those who receive a college education (the destined intellectual leaders of their generation) receive no instruction in science until a very late period in their educational course.

This exclusion of science from the early stages of education, and (for the great majority of the population) the consequent utter exclusion of science from their educational course is, I believe, the worst feature of our present system of general education. The introduction of science into the lower schools is the educational reform most urgently demanded.

One important reason for this reform is implied in what has been already said. If any knowledge or appreciation of science is to be generally diffused in the community, it must be by the introduction of instruction in science in the lower schools. Of the scholars who enter the primary school, only a small part reach the grammar school, and a far smaller part reach the high school. When we consider that the "people are destroyed for lack of knowledge"—that the preventable mortality due to simple ignorance of hygienic laws exceeds the slaughter of the bloodiest campaigns;—when we consider that not only is the duration of life lengthened, but its comforts and means of higher development prodigiously increased, by scientific knowledge;—when we consider that each man's knowledge or ignorance may not only affect for weal or woe himself and his own family, but may involve results whose ramifications in space and time are beyond our ken:—we cannot fail to recognize the importance of providing for all our population the means of gaining some acquaintance with those branches of knowledge on which the welfare of humanity so largely depends.

Another reason for this reform, though less obvious, is perhaps even more important. A sound system of education must take account of the natural order of development of the mental faculties. Nor need we be in any doubt as to what that order is. The perceptive faculties are the earliest to be developed; later come into activity the powers of abstract thought; later still does consciousness become reflective, and reveal the world of mind. The attention of a healthy and normally developing child is given almost exclusively to the phenomena of the external world. The questions which he asks his parents and other adult friends (if he has not been snubbed too many times in such questioning) relate almost exclusively to objects of sense around him. There are, indeed, miraculous children who speculate about the nature of the soul almost before they molt the long dresses of babyhood; but such

children usually die of precocious genius or early piety on the brain, and may therefore be disregarded in any discussion of general education. Young children in process of normal development are what some one has called the Buddhists—"unconscious materialists." They do not disbelieve in a spiritual world; they ignore it.

The early development of the perceptive faculties produces in the young child's mind a natural curiosity in regard to sensible objects, and therefore a natural aptitude for their study. There are three ways in which we may deal with this mental tendency. First, we may leave the child's curiosity about the external world to unrestrained and unguided indulgence. We may let the child run wild through field and forest, chase butterflies, rob birds' nests, and fill his pockets with caterpillars. He will grow up a young savage, with somewhat of a savage's field-craft and wood-craft, but with very little of valuable intellectual development. Secondly, we may repress the child's natural curiosity. And, in fact, that is about what is usually done. The child is taught to read as early as possible, and then the idea is sedulously inculcated that reading is the straight and narrow way that leadeth unto intellectual life. The story of Sir William Jones's mother answering all her son's questions with the words, "Read, and you will know," is told with express and implied encomiums upon her wisdom and her son's consequent vast erudition. Verily, the ghost of that good woman haunts our schools like a malignant spirit. The climax of success is reached when the little monk is snugly cloistered with his books, oblivious of the very existence of a world of light and music around him. And if he grows up to be one of the favored few who are permitted to enter the sacred precincts of the college, and there take up the long-deferred study of nature, he finds too often his powers of observation well-nigh atrophied by long disuse. I speak strongly, because I speak from experience. I feel daily that the efficiency of my work as a student and teacher of science is impaired by that vice of early education which repressed, rather than developed, whatever powers of observation nature had given. My professional life has been a perpetual struggle to rid myself of some of the mental habitudes induced by an unnatural education. I have not yet quite freed myself from the influence of Sir William Jones's mother. And what I have felt in myself I have seen in my students. It is

worse than making bricks without straw, to teach natural science to college juniors and seniors, in whom disuse has wrought so complete an atrophy of the powers of observation that they hardly know that there is an external universe.

Manifestly, the only right course in education is to furnish intelligent and sympathetic guidance to the child's natural curiosity. The study of nature should be introduced at the beginning of the educational course, instead of near its end. It should commence—not in the primary school, but in the nursery, before the child is old enough to go to school at all. A vast deal of knowledge may be smuggled into the child's mind without paying any duty of conscious toil. And such smuggling is forbidden by no laws of God or man. No child is hurt by knowing too much; though many a child is hurt by learning things in unnatural and unduly laborious ways. Whatever of useful knowledge a child gets while he thinks he is playing is clear gain. The sentiment,

“No profit grows where is no pleasure ta'en,”

may not be strictly true, but there is at least an important truth in it.

Some years ago I had the pleasure of a somewhat intimate acquaintance with a boy who, in his third summer, became very much interested in flowers, or, as he called them, “sowers,” for at that time his language, besides being very scanty in vocabulary, presented some marked dialectic peculiarities. Having obtained some specimens of the tawny day-lily (*Hemerocallis fulva*), he noticed the long slender bodies in the middle of the flower, and he asked his mother what they were. It seemed almost absurd to be teaching botany to a baby hardly more than two years old, but his mother, having large faith in the general principle that the best way to answer a child's questions is to tell the truth, told him that the things he had found were the stamens and pistil. Of course the baby did not know much about the objects which he examined. It was not time for his brain to be disturbed with matters of morphology and physiology. It was not time for him to learn that stamens and pistils are peculiarly modified leaves, or that they are respectively the male and female organs of reproduction. But his eyes were often busy that summer in looking for the stamens and pistils in various flowers, and in that simple matter of observation

he succeeded quite as well as some college juniors I have seen. And when, in after years, the time came for him to take up the study of botany more systematically, the objects of his study were to him not dim and unreal phantoms, but familiar friends.

To be continued.

FIGURING AGAINST WEEDS.

BY BYRON D. HALSTEAD.

THE weeds are among the worst enemies of the farmer. They cause a loss of many millions of dollars annually to the State of Iowa. This is not only in the diminution of crops but no small share of the outgo is in labor in order to prevent an entire loss of the crop.

Some persons, who as yet have secured no world-wide reputation for keen common sense, are inclined to look with much favor upon weeds. To their visionary minds they are simply a proper stimulus for the profitable tillage of the soil, and therefore may be considered as the friend instead of the enemy of the progressive farmer. If it were not for the weeds, which spring up and choke the neglected crop, there would not be sufficient incentive to good husbandry. Good and poor farming would be more equally rewarded. The man who hoes and the one who leaves his corn field for the shade and game along the wooded stream would stand a common chance of plenty at the harvest time. In short, weeds are the appointed means of putting a premium upon farm industry and furnish one reason why it does not pay to be shiftless.

This is turning the curse into a blessing, and if every one would practically make this turn there would need to be but little more said.

Weeds are a good deal like the sun and the rain in relation to the just and the unjust, with perhaps this variation, that the weeds seed abundantly on the neglected land of a shiftless farmer and these same seeds find their best places for growth in the clean rich fields of the careful husbandman.